

## AN EXPERIMENTAL INVESTIGATION ON THE MECHANICAL BEHAVIORS OF Al6063/B<sub>4</sub>C/Sic COMPOSITES

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### ABSTRACT

*The determination of designing MMC is to enhance the required characteristic of metals and porcelains to the base metals. Aluminium Metal Matrix Composites (AMMCs) are significantly important in the structural, aerospace, medicine, marine and automobile applications. The main aim of the current work is to prepare and study the microstructural and also mechanical behaviours such as impact strength, hardness, density and tensile strength of Al6063/B<sub>4</sub>C/Sic composites. The reinforced B<sub>4</sub>C and Sic particles with AMMCs were fabricated by stir casting technique. Al6063 matrix metal has been considered as the base metal to which reinforcements 2, 3.5, 5, and 6.5 wt. % of B<sub>4</sub>C particles and 0.5 % of Sic particles are added.*

**KEYWORDS:** Al6063 alloy, B<sub>4</sub>C and Sic Reinforcements, Stir Casting & Mechanical Behaviour

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### INTRODUCTION

The MMCs may be strengthened with the fibres, dispersoids and particles [3 &4]. The biggest interest in the composite materials is observed for those reinforced with hard ceramic particles due to the possibility of controlling their tribological, heat or mechanical properties of the selection of volume fraction, size, and distribution of the reinforcing particles in the matrix [1, 5]. They are more often, compared with the composite materials of their metals, and due to the possibility of replacing the costly and weighty elements prepared from the conventionally used ingredients[6]. Particle reinforced metal matrix composite represent a group of materials where the hardness, resistance of the reinforcement is combined with the toughness and ductility of metal matrix materials [9 &13]. Aluminium is the most frequently used matrix material due to its low density [16, 17 & 19].

In engineering, the type of composite used and its application vary significantly, as do the attributes that drives the choice of metal matrix composite in design [8]. For example, low cost, high specific modulus, and high weld ability of extruded aluminium oxide particle-reinforced aluminium are the properties desirable for bicycle frames [10]. Low weight, low cost, high wear resistance, enhanced great temperature properties, and the opportunity for integration in a huge portion of unreinforced aluminium is the concerns for proposal engine pistons [12 & 15].

For processing of AMMCs at industrial scale, the processing operations classified into two main groups, i.e. liquid state process and solid state process. Stir casting, compo casting and squeeze casting, spray casting and

in situ (reactive) processing, ultrasonic assisted casting comes under the liquid state process [21, 22]. Powder blending followed by consolidation (PM processing), diffusion bonding and vapours deposition technique comes under solid state process [20].

The objective of current research is to formulate and learn the mechanical behaviours of aluminium matrix composite material reinforced by 2, 3.5, 5, and 6.5 wt. % of  $B_4C$  and 0.5 % of Sic is added to each wt. % of  $B_4C$ .

## EXPERIMENTAL WORK AND PREPARING THE ALUMINIUM METAL MATRIX (AMMCS)

The composites were fabricated by stir casting method to ensure the uniform distribution of the  $B_4C$  and Sic reinforcement in the Al6063 alloy matrix. The Al6063 matrix metal was in the form of ingot, which was cut into small pieces to accommodate in the crucible. This metal matrix was heated in an electrical oven at  $750^{\circ}C$ . Reinforcements 2, 3.5, 5, and 6.5 wt. % of boron carbide ( $B_4C$ ) and 0.5 % of silicon carbide (Sic) is added to each wt. % of  $B_4C$ . This was preheated and added to molten metal and stirred continuously with a speed of 600 rpm for a period of 8 to 10 minutes.

**Table 1: Composition of Al6063 by Weight Percentage**

Elements	Weight Percentage of Al6063
Si	0.2
Fe	0.3
Cu	0.1
Mn	0.1
Cr	0.1
Zn	0.1
Ti	0.1
Aluminium	99.2



**Figure 1: Stir Casting Setup and Mould with AMMCs**

## MICROSTRUCTURAL STUDIES OF AMMCS

The trial grounding for microstructural revision was approved initially by polishing the divided trials with emery paper, after that the trials were refined by using diamond paste. The microstructure of the different specimens is cut from the different locations of the cast were observed with the help of the optical microscope to study the distributions of particles [1, 2]. The micrographs of prepared samples of Al6063 with reinforced weight percentages 2, 3.5, 5 and 6.5 of  $B_4C$  and 0.5 % of Sic are shown in the Figure 2 (a), (b), (c), and (d) respectively. The microstructural revision revealed the distribution of uniformity in weight percentages 2, 3.5, 5 of  $B_4C$  and 0.5 % Sic in the matrix, and a non-uniform is observed in the weight percentage 6.5 in  $B_4C$  and 0.5% Sic. This examination gives good interfacial bonding between  $B_4C$  particulates and Sic particulates with Al6063 alloy matrix.

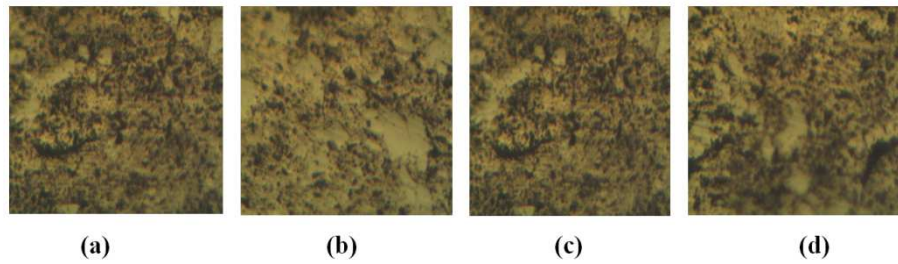


Figure 2: (a), (b), (c), (d) Optical Micrographs of Al6063/B<sub>4</sub>C/Sic Composites with 2 wt. %, 3.5 wt. %, 5 wt. % and 6.5 wt. % and 0.5% Sic Respectively

## ASSESSMENT OF MECHANICAL PROPERTIES

The composite specimens have been evaluated for tensile and impact strength, hardness, and density.

### Tensile Strength

Conducting tests with the computerized universal testing machine, the experimental values were obtained. The tensile strength is increased as 160.12Mpa, 169.32Mpa, 173.51Mpa up to the addition of reinforcements 2%, 3.5%, 5% of B<sub>4</sub>C and 0.5% of Sic respectively to the base material, and decreased as 167.80Mpa at 6.5% of B<sub>4</sub>C with 0.5% of Sic and this is due to the base material is not comfortably accommodating the reinforcements. The tensile strength has been increased because of strong interface bonding between the base metal and reinforcements. The deviation in tensile strength is as shown in the Figure 4.



Figure 3: Tensile Tested Specimen of Al6063/ B<sub>4</sub>C/Sic Composites

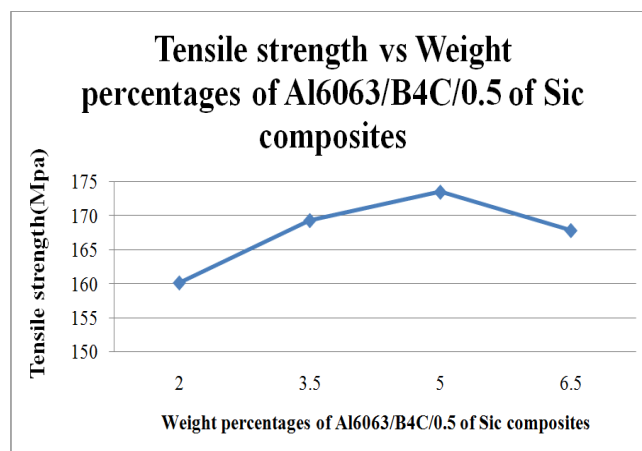


Figure 4: The Deviation in Tensile Strength of Al6063/ B<sub>4</sub>C/Sic Composites

### Impact Strength

By conducting experiments with the help of the Izod impact testing machine, the experimental values were obtained. The impact strength is increased as 26.52Mpa, 27.35Mpa, 28.14Mpa up to the addition of reinforcements 2%, 3.5%, 5% of B<sub>4</sub>C and 0.5% Sic respectively, of the base material, and decreased as 26.08Mpa at 6.5% of B<sub>4</sub>C and 0.5% of Sic and this is due to the base material is not comfortably accommodating the reinforcements. The variation of impact strength is as shown in the Figure 6.



Figure 5: Impact Strength Tested Specimen of Al6063/ B<sub>4</sub>C/Sic Composites

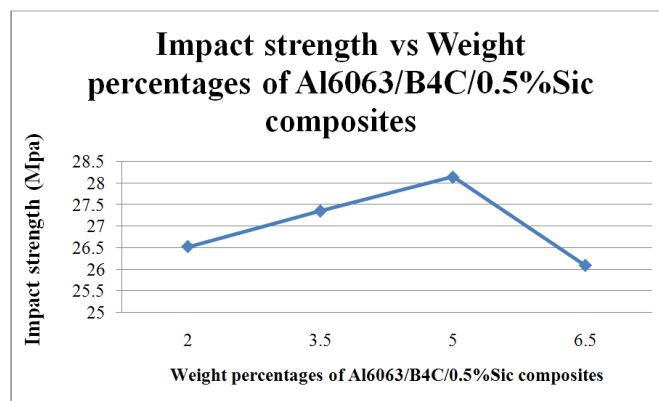


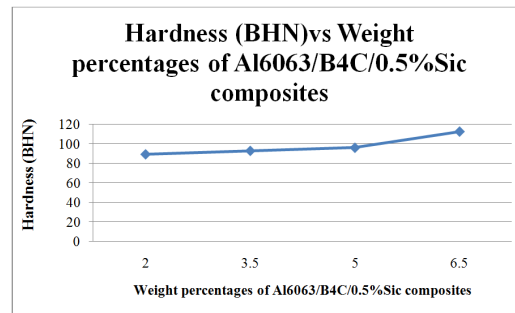
Figure 6: Impact Strength Tested Specimen of Al6063/ B<sub>4</sub>C/Sic Composites

### Hardness

The hardness is notable in the mechanical property of composite material, suppose if hardness of matrix material has precise low, and it is having limited applications. Hardness of base material enhanced because of the reinforcements of B<sub>4</sub>C particles and Sic particles is added in the base material.

The values of hardness of the Al6063/ B<sub>4</sub>C/Sic composites were acquired by the Brinell hardness tester. The deviation in hardness of Al6063/ B<sub>4</sub>C is as shown in the Figure 7.

Hardness of Al6063/ B<sub>4</sub>C/Sic composites is noticed that is 89.13, 92.67, 95.81, and 112.34 of weight percentages 2, 3.5, 5, 6.5 of B<sub>4</sub>C and 0.5% of Sic particulates respectively. So, Brinell hardness number in composites is more than the Al6063. A good increase in the hardness of the Al6063 has been observed with the addition of B<sub>4</sub>C and Sic particles.



**Figure 7: Hardness (BHN) of Al6063/ B<sub>4</sub>C/Sic Composites**

## Density

Density is the considerable factor in selection of material for several engineering applications to improve their efficiency. Determining the experimental values of density, the AMMCs samples of the measured volumes are weighed using a digital balance. The density of Al6063/ B<sub>4</sub>C/Sic composites are decreased by the means of increasing the weight percentage of reinforcements 2, 3.5, 5, and 6.5 of B<sub>4</sub>C and 0.5 %Sic and obtained density of Al6063/ B<sub>4</sub>C/Sic are 2.64gm/cc, 2.6350 gm/cc, 2.6214 gm/cc, and 2.613 gm/cc respectively.

**Table 2: Densities of Al6063/ B<sub>4</sub>C/Sic Composites**

S. NO.	Weight Percentages of Al6063/ B <sub>4</sub> C/0.5%Sic Composites	Density (gm/cc)
1	2	2.64
2	3.5	2.6350
3	5	2.6214
4	6.5	2.613

## CONCLUSIONS

The current research study based on the trial examination on B<sub>4</sub>C and Sic reinforced in Al6063 at different weight fractions. These are the following conclusions:

- The stir casting technique is healthy, appropriate and efficient for the grounding of Al6063/ B<sub>4</sub>C/Sic composites with preferred properties.
- Microstructural observations have been shown that B<sub>4</sub>C particles with weight percentages 2, 3.5 and 5 and 0.5% of Sic are the best distributor in the matrix material (Al6063) and good bonding between them.
- Tensile strength has been increased with weight percentages 2, 3.5, and 5 of B<sub>4</sub>C and 0.5% of Sic in the base metal.
- Enlargements on the impact strength of Al6063 matrix alloy were acquired by addition of weight percentages 2, 3.5 and 5 of B<sub>4</sub>C and 0.5% Sic particles.
- Hardness of the Al6063/ B<sub>4</sub>C/Sic greater than the base metal, this is due to the addition of the weight percentages of B<sub>4</sub>C and Sic.
- Density of Al6063/B<sub>4</sub>C/Sic has dropped in the cumulative weight percentage of the B<sub>4</sub>C and 0.5% of Sic. It is determined that, an Al6063/B<sub>4</sub>C/Sic composite have lower density than the pure Al6063.

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